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Towards a holistic approach of urban design.

Case study: Solar Access onto Chamberlain Square, Birmingham

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1. Introduction

Urban design is primarily and essentially three-dimensional design (Gosling and Maitland 1984), concerned with the shape, the surface and its physical arrangement of all kinds of urban elements; the basic components that make up the built environment at the level of buildings, spaces and human activities (Xia and Qing 2004). Gosling and Maitland (1984) state that the main objective of the urban designer is ‘to formulate and present the problem as accurately and vividly as possible’. Within the current design process and traditional methods of visualisation, (Xia and Qing 2004) state that current design methods only allow for a 2D representation of a space to be created. Architectural design practices will produce computerised renderings or 3D computer massing models to give a more accurate representation of the space. However there have been limited attempts at three dimensional computer representations which allow the user to get a greater sense of the urban space. Therefore, how to improve the quality of urban space and to express the design schema more effectively are problems that have been troubling urban designers for a long time.

Although notable pioneers have established ideals for the geometrical characteristic of square design; ideal dimensions, ratio of length to width and relationship to surrounding buildings and openings, we take the overall design of city centre squares and the resulting urban environment on a matter of trust, limiting the design of city centre squares. However, both (Gosling and Maitland 1984) and (Ratti and Richens 1999) identify that urban design is not purely to do with urban texture and geometrical characteristics, but also the non-visual aspects of environment, such as noise, wind and temperature, which contribute significantly to the character of an area. Ratti and Richens (1999) and Xia and Qing (2004) propose the practice of using computer software applications to analyse and simulate both visual and non-visual aspects of urban design, using three dimensional computer representations, would allow the designer to create more effective designs and improve the quality of city centre spaces. The paper will therefore propose that the incorporation of appropriate technologies, the candidate technologies selected for this research, into the urban design process could enable urban designers to more effectively test and develop their designs with consideration of pedestrian comfort, contributing to a more holistic approach to urban design. This paper adopts a case study methodology to report on the process and end results of applying one of these selected software applications to produce three-dimensional representations of Chamberlain Square to aid in assessing solar access into the square. The paper begins by giving a brief description of the urban development of Birmingham, highlighting its recent success in providing pedestrianised public spaces.

2. Urban Development of Birmingham

Birmingham expanded rapidly as a significant industrial town in the 18th century, with traditional street patterns and city centre squares arranged in an irregular grid pattern (Montgomery 1998). However, this city form suffered greatly through war damage and the post-war redevelopment that followed; modernist architecture, insatiable commercial interests and the intervention of the traffic engineer resulted in a city being perceived to have a poor image, and criticised by residents and visitors alike (Hubbard 1995) (Moughtin 2003). Nothing did more to fragment the urban structure of the city centre than the highway engineering projects implemented in mid 20th century. Montgomery (1998) states that the resulting construction of several ring roads sliced through the traditional urban blocks and acted as 'concrete collars' around the city centre, leaving a fragmented urban structure and a confused public realm. By the end of the 1960's, the majority of the urban structure had been primarily designed for motor vehicle accessibility, with the provision of pedestrian safe streets and public areas being widely neglected.

Birmingham council's implementation of a car dominated city centre and neglect of safe pedestrian routes and spaces continued until the late 1980's, when Hubbard (1995) states that the amalgamation of Birmingham's planning and architecture departments signalled the city council's desire to raise design standards in the city. Montgomery (1998) highlights that it became clear to Birmingham Council that while roads were necessary, they should not become barriers to pedestrian movement or important views and that the physical structure of the city centre would have to be improved if Birmingham were to be successful in changing its image. This resulted in Birmingham Council commissioning a comprehensive urban design study of the city centre in 1986. Birmingham council hired the notable urban design Francis Tibbalds to carry out the study, which Hubbard (1995) states was the first study of its kind in the country. Completed within four years Hubbard (1995) highlights Birmingham Urban Design Study (Tibbalds 1990), suggested ways the city could overturn its image of an unfathomable concrete jungle, calling for the city to become more 'legible' and user-friendly by enhancing accessibility and increasing street-level activity. Montgomery (1998) states that Tibbalds (1990) also highlighted the importance of new and improved city squares to the western side of the city centre to enhance the identity and distinctiveness of the quarters they are located in, and provide new pedestrian links between the quarters. Since the early 1990's Birmingham City Council has been implementing its urban design strategy to develop new and improved city squares and interconnected streets (Corbett 2004). Montgomery (1998) highlights the resulting creation or improvement of five pedestrianised public squares along the new strategic link between the New Street railway station and Brindley Place and the interconnecting streets, now provides pedestrians with a sequential experience of interconnected public spaces, with the viewer continually led onwards to new delights.

2.1. Chamberlain Square

Montgomery (1998) states that the second public space in the sequence of squares leading from New Street railway station towards Brindley Place is the steeply sloping Chamberlain Square. Located off the north-western corner of the main square in Birmingham, Victoria Square, Chamberlain Square measures 58 m by 69 m and is divided into two main subspaces by a change in level of about 6 m, an upper and lower terrace. Sweeping steps located in front of the library connect the subspace and also form a small amphitheatre within the square. The unique amphitheatre design of square also has a sunny aspect with the steps facing south, encouraging people to sit and relax on these steps during good weather. Montgomery (1998) also highlights that Chamberlain square has been designed to provide a

fast moving pedestrian channel with the inclusion of a shaped slope that links the entrance from Victoria Square to the Paradise Forum, continuing the route from the railway station to Brindley Place. The abundance of public buildings that surround the square; the classical town hall, the city museum and art gallery, as well as by a modernist city library and the Paradise Forum retail mall and the key link it provides results in Chamberlain Square experiencing a high pedestrian use throughout the day. This, along with its unique amphitheatre design also enabling the square to be used for public events results in pedestrian comfort being crucial within the square's design.

2.1.1. Assessing the Geometrical Characteristics (Times 12pt, italic, spacing 14pt before and 3pt after)

The square is, first and foremost, a meeting place for people, a place for activities, communication and interaction to take place. In creating a successful square, the space must give a sense of enclosure and it must provide a sense of visual comfort. The dimensions of a square should be related to human scale and ratios of length to width and the relationship between the space and the surrounding buildings all play a significant role in the sense of enclosure and visual comfort of a square. An assessment of the geometrical characteristics of Chamberlain Square shows that many of its geometrical properties fall within the ideals stated by notable authors of square design (Table 1). However, one differing observation of the geometrical properties of Chamberlain Square is the relationship between the square and its openings. Sitte (1889) identified from his examination of ancient squares that in very few cases nobody entering a square by one of the streets can get any extended view out of it along another street. Thus Sitte (1889) concluded that to create a successful sense of enclosure, it should not be possible to see out of the square along more than one street at a time, highlighting that this is best achieved when openings into a square are placed at right angles to each other. An examination of the openings into Chamberlain square shows that all but one of the openings allows a user to see out of the square before they have entered (Table 2).

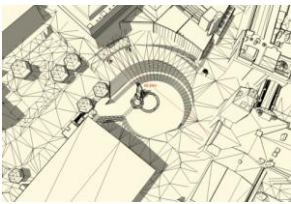

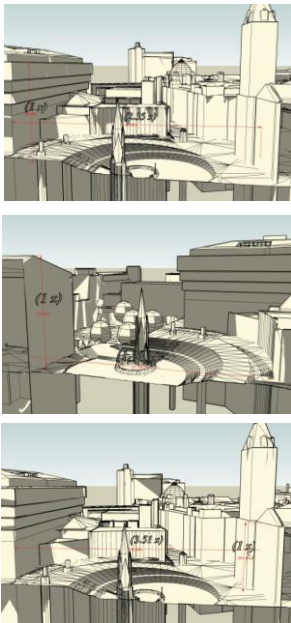
Geometrical Characteristic	Image	Ideal	Chamberlain Square
Square Dimensions		50m by 70m Corbett (2004)	57.89m By 68.89m
Ratio of length to width		3:2 or 1.5:1 Vitruvius (1914) To 2:1 Alberti (1475)	1.19:1
Ratio of height of surrounding buildings to their perpendicular distance		2:1 To 3:1 Corbett (2004)	2.35:1 1.98:1 3.51:1

Table 1 – Geometrical characteristics of Chamberlain Square

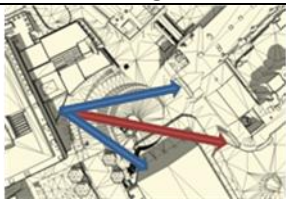
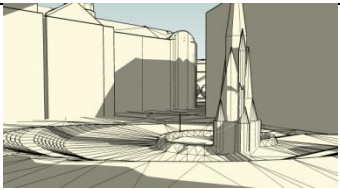



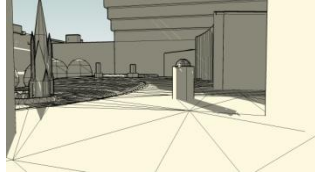





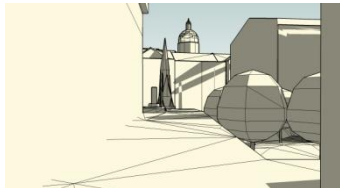
Opening	Image	View	Enclosed View
Paradise Forum			No
Congreve Passage			No
Chamberlain Square			No
Victoria Square			No
Paradise Circus			Yes
Birmingham City University			No

Table 2 – Openings onto Chamberlain Square.

The sense of enclosure for a square is also linked to the relationship of surrounding mass and size of openings into a square. Carmona et al. (2003) states that for Sitte, enclosure was the primary feeling of urbanity, and his overarching principle was that ‘public squares should be enclosed entities’. This does not refer to the complete enclosure of a continuous ring of buildings, but a general sense of enclosure resulting from a fairly continuous frame of buildings, where the breaks in which are small in contrast and not too obvious. Both Unwin (1909) and Sitte (1889) examined a series of ancient squares, and concluded that whether from accident or design, the entrances into the squares are usually so arranged that they break the frame of the surrounding buildings very little, if at all. However, no dimensions are given for the ideal or even maximum and minimum size of openings into a square, nor have such dimensions been found from currently reviewed literature. Smith (1980 - 81) does propound a rule of thumb about how much of a form is necessary to imply the rest, stating that if you build roughly three-fifths (60%) of a form the mind will recognize the complete figure, with

the corners having more figural power than other portions. A study of the amount of surrounding form shows that Chamberlain square has roughly 65% of surrounding mass, with the most significant gap in the surrounding form located in the southern corner of Chamberlain Square. Whether by accident or design, this significant gap in the frame could allow a greater amount of sunlight to be admitted into the square throughout the year, which is key in square design and providing a comfortable environment. Corbett (2004) highlights that for city squares that exist in temperate climates, such as Britain, it is essential that they receive as much direct sunlight as possible, especially during the times of peak use, to help provide a warm environment that is comfortable to be in. This is in contrast to city centre squares located in southern Europe studied by Unwin (1909) and Sitte (1889), where a square is designed to provide shade from the high temperatures. However, in both cases the square has been designed to provide a comfortable environment for the majority of year. A study is therefore needed to further examine the importance of the size and locations of openings onto Chamberlain square in creating a comfortable environment.

3. Urban Quality

Although notable pioneers of square design, Sitte (1889), Vitruvius (1914), Unwin (1909), etc, have studied a wide variety of city centre squares to establish their geometrical ideals for what makes a square psychologically pleasing for an user to occupy, square design is also concerned with the non-visual aspects of environment. The surrounding noise and enclosed microclimate also contribute significantly to the character of an area and the levels of pedestrian comfort. To date the research has carried out an extension review of available technologies that can help to model, analyse and simulate the non-visual effects concerned with urban design and improving levels of pedestrian comfort within city centre squares. By applying a filtering process that related to the key requirements of the research, the identified software applications were reduced to only those applications that were considered the most appropriate for adoption into the urban design process. A more extensive study, trial and validation process was then applied to select one application within four areas of square design established to improve levels of pedestrian comfort (Table 3).

Pedestrian Movement	•Legion Studio with Legion 3D
Wind Analysis	•Star-CCM+
Noise Mapping	•CadnaA
Solar Access and Thermal Comfort	•TownScope

Table 3 – Software applications selected for use within the research

3.1. Microclimate

The microclimate of a square is an important issue in its design, knowing how to best control aspects such as, sunlight, wind, heat and temperature, and noise, is important if the square is going to provide comfortable conditions for its occupants to be in. Corbett (2004) highlights that the choice of materials within a city square and on the buildings around also have a significant effect upon its microclimate and comfort levels and should be guided by the objective of avoiding extremes of microclimate. Carmona et al. (2003) highlight that the configuring of space, and use of surrounding buildings, walls, trees, canopies and arcades for shade and shelter can also help to make conditions in a square more acceptable. Childs (2004) states that squares should also be designed to aid migration both by, zoning activities and by

matching peak use times with appropriate microclimates. Marcus and Francis (1998) highlight that when squares are designed for stationary use (standing, sitting) then they should have as much area as possible falling within the comfort zone. This study will concentrate on assessing the design of Chamberlain square in providing a comfortable environment for its occupants to be in. The study will focus on the amount of sunlight admitted into the square by applying the selected software application TownScope.

3.1.1. TownScope – Setting up the model

TownScope contains analysis tools available to analyses and simulate; solar access, thermal comfort in an urban open spaces, sky opening, view lengths and visibility analysis (Azar 2007). TownScope is capable of importing a variety of file formats to produce the 3D geometry of the urban realm, including; 3Ds, DXF and OBJ and also includes the capability of adding meteorological parameters (humidity, clouding, etc.) and vegetation masks, create terrain from 3D points and to render opacity and daylight shadings. TownScope, along with relative weather data, will be used to assess the solar access into Chamberlain square and examine the relationship between the significant gap in the surrounding form located on the southern corner of Chamberlain Square and the resulting urban environment.

Before any analysis can take place, a representation of Chamberlain Square and its urban environment needs to be created. The process of setting up the urban model is show in Figure 1. For an accurate study of Chamberlain Square to take place, several data sources are needed to assess the solar access of the urban space. Weather data has been obtained from www.meteoarchive.com, who offer quick and easy access to historical worldwide weather data necessary for input into TownScope. To define the surrounding materials TownScope offers a small database of the most common materials found in the urban realm, including their relative properties. 3D model data of Chamberlain Square was purchased from Zmapping, who currently offer detailed city model data for a selection of UK cities. Along with credited data sources, a computer with appropriate specification is needed to run the necessary calculations (Table 4).

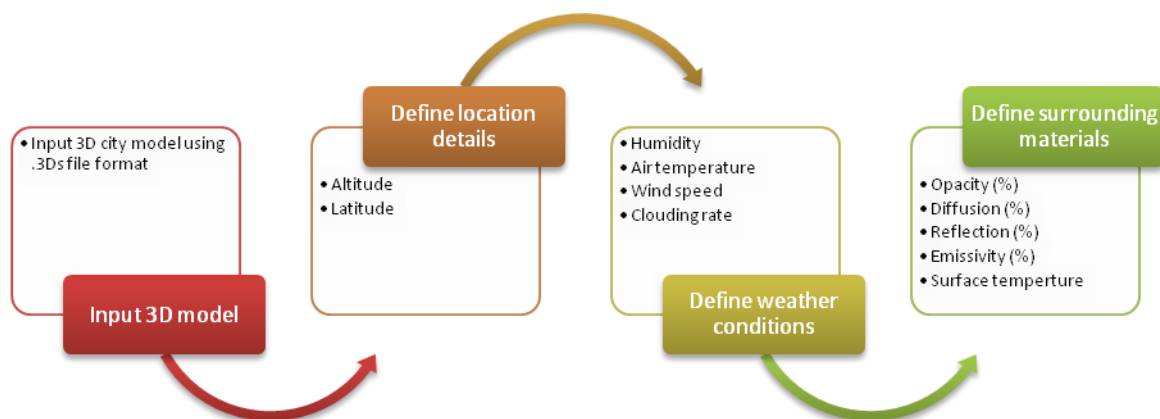


Figure 1 – Process of setting up the urban model in TownScope

Specification	TownScope (Minimal Requirements)	Computer Used
Operating System	NT, 2000, XP, VISTA, Windows7	XP
Processor	Not Stated	2GHz
RAM	512MB	3GB
Disk Space	20MB	5GB
Graphics	64 MB VRAM	128 MB VRAM

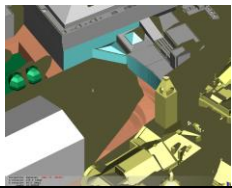
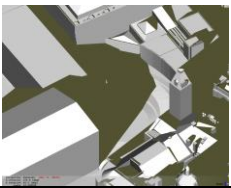
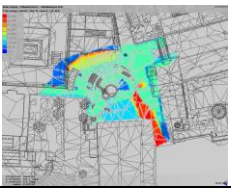
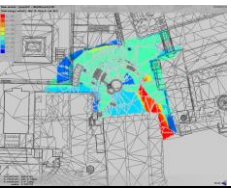

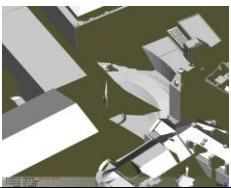
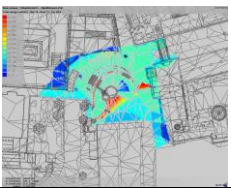
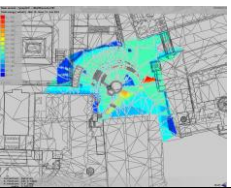
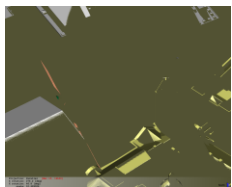
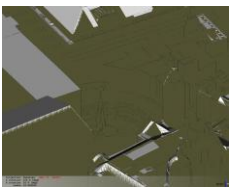

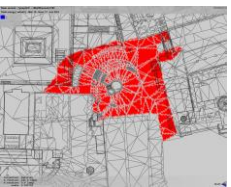
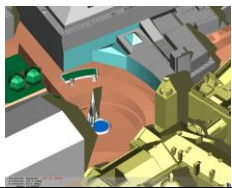
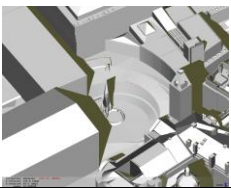
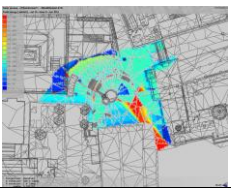
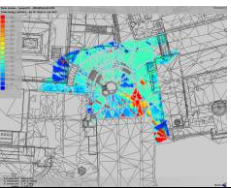
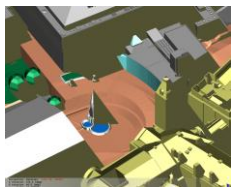
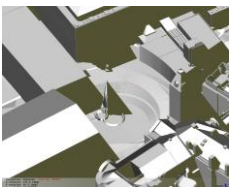
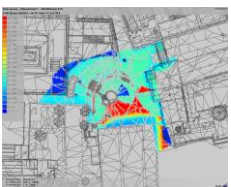
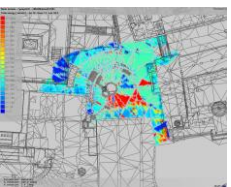
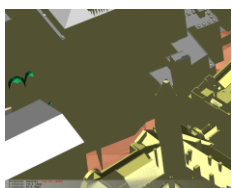
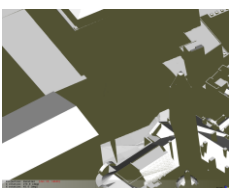
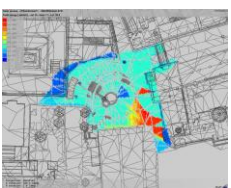
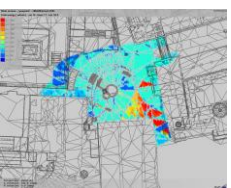
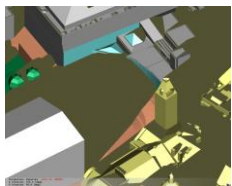
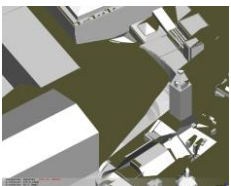
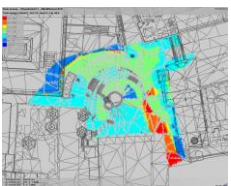
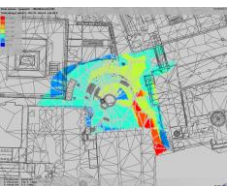

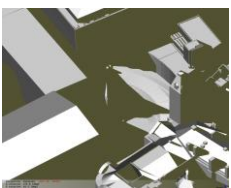
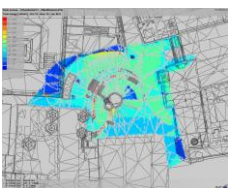
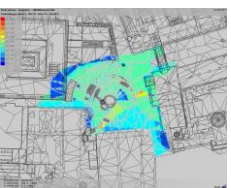
Table 4 – Comparison of required computer specification

3.2. Sunlight

Carmona et al. (2003) state that sunlight penetration into urban places helps to make them more pleasant places, encouraging outdoor activities and improving health by providing the body with vitamin E. Sunlight also provides natural lighting to a public space, Carmona et al. (2003) state that natural lighting makes an important contribution to the character and utility of public space, and the play of light in urban spaces also has aesthetic dimensions. The amount of visible sky, particularly overhead, where it is brighter than at the horizon, is crucial to the quality of day lighting. The value of sunlight penetration varies over the seasons and, while places in the sun are desirable at some times of year, at other times shade is preferred. However, Marcus and Francis (1998) suggest that a square should be located so as to receive as much sunlight as its surrounding environment will permit. To do so, Carmona et al. (2003) state that two major issues are of concern; orientation and overshadowing and shading. Carmona et al. (2003) highlights that if overshadowing is to be avoided during winter months (when solar gain is most advantageous), the spacing between buildings is very significant.

3.2.1. The study

As a demonstration of one of the applications of TownScope within the research and the urban design process, a study of the solar access into Chamberlain Square will be carried out. The study of Chamberlain Square is focused on the amount of sunlight admitted into the square at different times of the year (March 15th, July 15th and Oct 15th) and at different times of the day (09:00, 13:00 and 17:00). This should allow an understanding of the variations in solar access throughout the year at key times of pedestrian activity to be gained. TownScope will also be used to assess the relationship between the degree of solar access into Chamberlain square and the importance, if any, of the significant gap in the surrounding frame located in the southern corner. To assess the importance of the gap in the surrounding frame, a test building in proportion to the surrounding buildings in Chamberlain Square, will be modelled to fill in the gap. The results of the study are shown in Table 5.

Date	Time	Shading Analysis		Solar Access – Total Energy (w/m2)	
		Existing	Test Case	Existing	Test Case
March 15th	09:00				
	13:00				
	17:00				
July 15th	09:00				
	13:00				
	17:00				
October 15th	13:00				
	17:00				

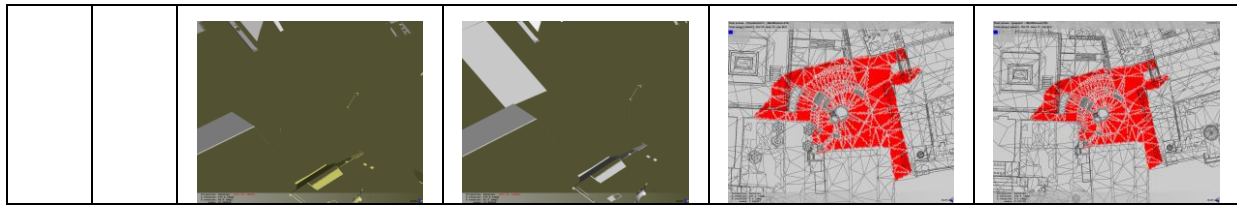


Table 5. Solar Analysis of Chamberlain Square – Existing and Test Case

The results presented in Table 5 of solar access and resulting shade into Chamberlain Square shows that during peak pedestrian activity during lunchtime hours, around 13:00, the significant gap located in the southern corner of Chamberlain Square does play an important role in the amount of sunlight admitted into the space. This is not so much the case during the summer months, but certainly there is reduction in the amount of solar access into Chamberlain Square during non summer months, when the sun is lower in the sky. However, the most significant effect on the amount of solar access into Chamberlain Square throughout the year appears to be the height of the library located on the Eastern corner. It appears that regardless of the time of year, the library casts a shadow over the width of the square from the early evening. The analysis of solar access into Chamberlain Square has also highlighted the importance of the wide opening between Chamberlain Square and Victoria Square, especially during the early hours, in providing the majority of sunlight into the space. It appears therefore from the study of solar access into Chamberlain Square, that the significant gap located in the southern corner and the wide opening from Victoria Square are key in increasing the amount on sunlight admitted into the space throughout the year at key times of pedestrian activity, especially during morning and evening in the non summer months.

3.3. Further application of the software

TownScope has only been used in this paper to demonstrate its capabilities of analysing solar access (Total energy w/m^2) and resulting shade, in assessing one change to the surrounding form of Chamberlain Square for selected times of the year. If needed, TownScope can be used more precisely to assess solar access, including; direct, diffused and reflected energy, total sunlight time and total shade time, to gain a greater understanding of the impact of the squares design. The software can also more importantly be used to assess the comfort levels of pedestrians moving through the space, including their perceived temperature and sweat rates. This can help to design squares to better suit pedestrian comfort levels throughout the year.

3.4. Limitations of the Software

Although TownScope was successfully used to assess the solar access into Chamberlain Square, the software does have a number of limitations. The most prominent limitation with the software is the time needed to carry out the necessary analysis. Due to the complexity of the selected square and therefore the complexity of the imported Zmapping model (number of faces), the software took a significant time to generate the results. Solar access analysis took in the region of 3 hours per analysis (selected model and day) to complete using one standalone computer (Table 4). This amount of time is inappropriate to effectively use the software to aid in the design of city centre squares. A means of reducing this time will need to be established, either by upgrading the current computer hardware or by networking a number of computers to cope with the analysis. Another limitation of TownScope in relation to the complexity of the model is that the resulting coloured map, representing the varying solar access values, is segmented by the different faces. The software therefore appears to work best, and present better results when analysing a flatter and less detailed terrain or model.

4. Conclusion

Birmingham has made a major effort since the early 1990's to revive the city centre and regain civic pride after being devastated by the post-war modern redevelopment and the overpowering highway projects that scared and fragmented the city form. Birmingham now provides an example of how a city can create new and improved city squares and interconnected streets, transforming a previous car-dominated city centre, into an attractive place and exciting urban realm, one example being Chamberlain Square. With its unique amphitheatre design providing a sunny aspect with the steps facing south, encouraging people to sit and relax during good weather, along with a number of public buildings surrounding the square, results in Chamberlain Square experiencing a high pedestrian use throughout the day. Therefore ideal pedestrian comfort levels within Chamberlain square are crucial in providing a comfortable environment for its occupants. The study of the geometrical characteristic of Chamberlain square showed that it fell within many of the ideals set by notable authors of square design. However, the relationship between the square and its openings differed from the ideals stated by Sitte (1889). As these ideals were established from the review of squares in southern Europe where the provision of shade is more important, the study hypothesised that the significant gap located in the southern corner of the Chamberlain square could be there to increase the level of solar access. TownScope was used to assess to solar access levels within Chamberlain square. The results showing that the significant gap located in the southern corner and the wide opening from Victoria Square are key in increasing the amount on sunlight admitted into the space throughout the year, especially during non summer months. However, although TownScope was successfully used to assess the solar access into Chamberlain Square, and could successfully be adopted within the urban design process to assess solar access and pedestrian thermal comfort, the software does have a number of limitations. Most significantly the time needed to carry out the necessary analysis (3 hours) is currently inappropriate to effectively use the software to aid in the design of city centre squares and a means of reducing this time is needed.

5. Future Research

Square design is not only concerned with the analysis of the geometrical properties of a square and the resulting solar access, as presented in this paper. To greatly improve the design of city centre squares, the design must also take into account the non-visual aspects of environment; the surrounding noise and enclosed microclimate (temperature and wind) which also contribute significantly to the character of an area and the levels of pedestrian comfort. Future research will include the application of the select software applications (Table 3) to assess city centre square design in relation to the non-visual effects of urban design and the improvement of levels of pedestrian comfort. The paper therefore concludes by proposing that by incorporating the selected software applications (Table 3) into the urban design process will allow urban designers to effectively test and develop their designs. It is proposed that this will aid in the improvement of the design of city centre spaces and the comfort of users within the spaces. The further incorporation of results from these software applications into Virtual Reality (VR) technologies would also allow users to gain a *greater sense* of the urban space and to communicate the design and its effect on urban quality aspects more effectively.

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